Abstract

This presentation gives a general overlook of the engineering efforts that are necessary to meet science mission requirement especially for Earth Science missions. It provides brief overlook of NASA's current missions and future Earth Science missions and the engineering challenges to meet some of the specific science objectives. It also provides, if time permits, a brief summary of two significant weather and climate phenomena in the Southern Hemisphere: El Niño and La Niña, as well as the Ozone depletion over Antarctica that will be of interest to IEEE intercom 2009 conference audience.
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IEEE Intercon 2009
Arequipa - Peru
Agenda

• Introduction
• Overview of NASA Science and Technological Accomplishments
• Past, Present and Future Missions
• Earth Science
• General Engineering and Technological Challenges
• Summary/Questions and Answers
This year NASA is celebrating 50 years of scientific and technological excellence. NASA has powered us into the 21st century through signature accomplishments that are enduring icons of human achievement. Among those accomplishments are technological innovations and scientific discoveries that have improved and shaped our lives on Earth in a myriad of ways.

NASA scientists and engineers look forward to a promising new era of inspiration, innovation, and discovery.
The NASA Vision
To improve life here,
To extend life to there,
To find life beyond.

The NASA Mission
To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
... as only NASA can.
NASA Headquarters: Provides overall guidance and direction to the agency.

NASA conducts its work in four principle organizations, called directorates.

- **Aeronautics**: New Flight technology, enable a safer, more secure, efficient, and environmentally friendly air transportation.
- **Science**: Exploring the Earth-Sun system, our own solar system, and the universe beyond.
- **Exploration**: Direct the identification, development, and validation of exploration systems and technologies.
- **Space Operations**: Extend the duration and boundaries of human space flight to create new opportunities for exploration and discovery.
Science Directorate

Earth
Improve human understanding of our home planet

Heliophysics
Exploration of the Sun, Its effects on Earth and the planets of the solar system, and space Environmental conditions And their evolution

Planets
Advancing scientific Knowledge of the origin And history of the solar system, the potential of life elsewhere

Astrophysics
Discovering the origin, the structure, evolution, And destiny of the Universe, Searching for Earth-like planets
There are ten field centers and other installations that conduct day-to-day science and engineering work:

- Kennedy Space Flight Center - Florida
- Johnson Space Flight Center - Texas
- Langley Space Flight Center - Virginia
- Goddard Space Flight Center - Maryland
- Ames Space Flight Center - California
- Dryden Flight Research Center - California
- Stennis Space Flight Center - Mississippi
- Marshall Space Flight Center - Alabama
- Glenn Research Center - Ohio
- Jet Propulsion Laboratory
Science and Engineering

- Scientist: Vision for discovery, study, exploration – the need to know why becomes a science mission objectives
- Engineer: How to meet science objectives and how to get it done through creativity, innovation, use of technology or creating new technology
- There is a significant amount of synergy between both to accomplish mission objectives.
NASA Studies Planets...

Runaway greenhouse: No water cycle to remove carbon from atmosphere

Loss of carbon: No lithosphere motion on Mars to release carbon

Earth Harbor of Life

...and None Are So Thoroughly as Planet Earth!
Earth Science Vision

Is dedicated to understanding the Earth as an integrated system and applying Earth System Science to improve prediction of climate, weather, and natural hazards using the unique vantage point of space.
Science Questions

How is the Earth changing and what are the consequences of life on Earth?

• How is the global Earth system changing?
• What are the primary forcings of the Earth system?
• How does the Earth system respond to natural and human-induced changes?
• How well can we predict future changes in the Earth system?
• What are the consequences of changes in the Earth system for human civilization?
Missions that address science questions
Decadal Survey Missions/Future Missions

Near-Term Missions: 2010–2013
Mid-Term Missions: 2013–2016
Late-Term Missions: 2016–2020
NASA System Engineering

NASA has a well established System Engineering Project Life Cycle for:

- Design,
- Realization,
- Technical management,
- Operations,
- Retirement of a system or mission.
NASA Project Life Cycle

- Pre-Phase A: Concept Studies
- Phase A: Concept and Technology Development
- Phase B: Preliminary Design and Technology Completion
- Phase C: Final Design & Fabrication
- Phase D: System Assembly, Integration & Test Launch
- Phase E: Operations & Sustainment
- Phase F: Close Out
New Technology

Radiometer

- Measures wavelengths typically in the microwave domain
- A hybrid of optical and RF techniques are used
- An antenna picks up an RF signal, and microwave engineering techniques are used to detect, down-convert and digitize the signal
- Very useful in the planetary science arena, or wherever water detection is useful
- Aquarius mission will provide global maps of salt concentration on the ocean surface. This is important because the salt concentration affects the ability of the oceans to store and transport heat. This in turn affects Earth's climate and the water cycle.

L-Band Microwave Radiometer: The Aquarius/Sac-D Passive Salinity Sensor L-Band Microwave Radiometer will be launched in 2010
JWST Technology Milestones

- Mirror Phasing Algorithms
- Sunshield Membrane
- Beryllium Primary Mirror Segment
- Cryocooler
- Near-Infrared Detector
- Mid-Infrared Detector
- Cryogenic ASICs
Remote Sensing Instruments:  
*Multi-Object Spectrometers*

- Split the light received from their targets into component wavelengths for measuring and analyzing. Typically sensitive in the infrared, visible, and ultraviolet wavelengths.
- Use electronic detectors, such as CCDs, and return data representing the intensity of various parts of the spectrum observed.
- An imaging or mapping spectrometer provides spectral measurements for each of the many pixels of an image the instrument obtains, thus supplying spectral data for many different points on a target body all at once.
- On ground based telescopes, a metal plate with holes punched in locations corresponding to desired targets is inserted at a focus point.
- On NIRSpec, a microshutter array enables scientists to select multiple interesting targets, while eliminating unwanted ones.

*NIRSpec*: The Near-Infrared Spectrograph (NIRSpec) (bottom) will be launched in June 2013 as part of the JWST mission (top). The MSS and DS are being built in-house at Goddard.
Radar

- Actively measures properties of targets by bouncing RF energy off of them using wavelengths typically in the microwave domain
- An active RF emitter sends signal towards the target
- An antenna picks up the reflected RF signal, and microwave engineering techniques are used to detect, down-convert and digitize the signal
- Very useful in rainfall measurement and altimetry
- Typically consist of: RF Emitter, antenna/reflector, detector, electronics to read detector, power supply, processor and software to process data, structure, thermal system, calibration system, scan mechanism
- GPM is comprised of a dual-frequency radar and a microwave imager. The radar will have the capability to make detailed, three-dimensional measurements of cloud structure, rainfall, and rain rates.

Artist rendition of GPM satellite. GPM will launch in summer 2013.
Magneto-Multiscale Mission (MMS)-FPI

- Four identical spin stabilized (3 RPM) spacecraft formation launched in 2014 flying in a tetrahedron to measure Electric and magnetic fields, Energetic particles and Hot plasma composition.

- Fast Plasma Instrument is being built by GSFC scientists and engineers.

Prototype Optics

Sensor Model

SMART ion and electron measurements at the speed of nature...
Robotics

- Use of robotics to explore the moon and journey beyond
- Applications for space mission and related terrestrial endeavors
- Applications:
  - Driving
  - Flying
  - Landing
  - Small body orbiting
  - Sampling
  - Simulations
  - Onboard service
Assembly Aura

Clean Room Activities
Engineering Challenges

- **System Engineering**: Improve processes to consolidate sciences mission requirements, implementation and operations for both the space element and the ground element.
- **Design**: Strive to develop new materials and methods of structural design.
- **Communications**: Transmission of high volumes of data - efforts aimed at broadening the bandwidth
  - the capacity for carrying data along a communications channels
  - for data sent from Earth to low orbit and outer space destinations.
  - development of new technology space and ground networks
- **Information Technology (IT) Security**: Data and system protection against intrusion.
Summary

“NASA scientist and engineers look forward to a promising new era of inspiration, innovation, and discovery”.

“We will go where nobody has gone before”